A Comprehensive Overview and Comparative Analysis on Deep Learning Models: CNN, RNN, LSTM, GRU

Year: 2023 | Citations: 289 | Authors: Farhad Shiri, Thinagaran Perumal, N. Mustapha, Raihani Mohamed

Abstract

Deep learning (DL) has emerged as a powerful subset of machine learning (ML) and artificial intelligence (AI), outperforming traditional ML methods, especially in handling unstructured and large datasets. Its impact spans across various domains, including speech recognition, healthcare, autonomous vehicles, cybersecurity, predictive analytics, and more. However, the complexity and dynamic nature of real-world problems present challenges in designing effective deep learning models. Consequently, several deep learning models have been developed to address different problems and applications. In this article, we conduct a comprehensive survey of various deep learning models, including Convolutional Neural Network (CNN), Recurrent Neural Network (RNN), Temporal Convolutional Networks (TCN), Transformer, Kolmogorov-Arnold networks (KAN), Generative Models, Deep Reinforcement Learning (DRL), and Deep Transfer Learning. We examine the structure, applications, benefits, and limitations of each model. Furthermore, we perform an analysis using three publicly available datasets: IMDB, ARAS, and Fruit-360. We compared the performance of six renowned deep learning models: CNN, RNN, Long Short-Term Memory (LSTM), Bidirectional LSTM, Gated Recurrent Unit (GRU), and Bidirectional GRU alongside two newer models, TCN and Transformer, using the IMDB and ARAS datasets. Additionally, we evaluated the performance of eight CNN-based models, including VGG (Visual Geometry Group), Inception, ResNet (Residual Network), InceptionResNet, Xception (Extreme Inception), MobileNet, DenseNet (Dense Convolutional Network), and NASNet (Neural Architecture Search Network), for image classification tasks using the Fruit-360 dataset.